2025 Physics Almanac of Experimental Outcomes

The Year Physics Stopped Adding Particles and Started Closing Doors

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Abstract

2025 marked a decisive shift in fundamental physics. Across neutrino physics, dark-matter searches, precision measurements, and early-universe observations, the dominant experimental outcome was not discovery but exclusion. Sterile neutrinos lost substantial parameter space, canonical and sub-GeV dark-matter candidates returned null results at record sensitivity, cosmological structure continued to appear earlier than particle-centric models naturally predict, and precision observables compressed the room for parameter-based extensions. This Almanac curates a small set of high-signal results from 2025 and provides a unified interpretation within Quarkbase Cosmology. The common pattern is not the need for new particles, but the need for deeper structure: internal modes, geometric dynamics, and a real physical medium.

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Scope and criteria

- **Time window:** results published or finalized up to 31 Dec 2025.
- **Selection rule:** few items, each with decisive experimental weight (null results or stabilized tensions).
- **Method:** primary sources first; divulgation only as entry points.
- **Interpretation:** explicit, testable alignment with Quarkbase Cosmology principles; no speculative inflation.

How to read this Almanac

Each section contains:

1. the **news hook** (what was reported),
2. the **primary study** (what was actually measured),
3. a **Quarkbase Cosmology reading** (what structural lesson follows, without forcing).

Quarkbase Cosmology Almanac 2025

I. The Sterile Neutrino Loses Ground (KATRIN)

The news

Late December 2025 science outlets reported that *"a particle that could have rewritten physics has been ruled out after 36 million measurements"*, referring to the latest results of the **KATRIN** experiment. The claim is clear: **no evidence for sterile neutrinos** has been found in the most sensitive direct measurement to date.

The study (primary source)

KATRIN Collaboration (2025), *Nature*
"Sterile-neutrino search based on 259 days of KATRIN data"

Key facts:

- **259 days** of high-statistics data.
- **∼36 million** beta-decay electrons from tritium.
- Analysis focused on the last **∼40 eV** below the beta endpoint.
- Result: **no spectral distortion ("kink")** compatible with a sterile neutrino state.

- Strong exclusion of parameter regions motivated by the **Gallium anomaly** and direct tension with **Neutrino-4** claims.

This is not an indirect cosmological inference, but a **direct spectral-shape test** performed in a controlled laboratory environment.

Why this strengthens Quarkbase Cosmology

1. Experimental pressure against ontological inflation The sterile neutrino is not required by first principles; it is an **auxiliary particle**, introduced to patch anomalies within the Standard Model framework. KATRINs null result removes a large fraction of the available parameter space for this patch.

Quarkbase Cosmology, by contrast, **never required sterile neutrinos**. From its foundation:

- The neutrino ($N = 1$) is **real, unique, and fundamental**.
- Oscillations arise from **internal mode interference** within a single entity propagating through the Ψ-field.
- No additional invisible species are postulated.

When experiments systematically eliminate "extra particles", frameworks based on **internal structure rather than particle multiplication** gain relative explanatory power.

2. A shape-based test favors structural interpretations KATRIN is sensitive to the **geometry of the beta spectrum**, not merely to counting rates or cosmological fits. A sterile neutrino would necessarily leave a **distinct geometric signature**.

Quarkbase Cosmology is precisely a **structural theory**: physical phenomena emerge from internal modes and field geometry, not from adding weakly interacting entities. The absence of the expected spectral feature is therefore consistent with a picture in which oscillations do not correspond to additional mass eigenstates.

3. Oscillations without new particles remain viable—and cleaner What experiments robustly measure are:

- phase-dependent oscillations,
- coherence over macroscopic distances,
- environmental (matter) effects.

None of these observations **force** the existence of sterile neutrinos. KATRIN reinforces this distinction: **the phenomenon is real; the extra particle is optional—and now strongly disfavored**.

Quarkbase Cosmology removes the optional entity altogether and explains oscillations as an intrinsic dynamical property of the neutrino–Ψ system.

Key takeaway

2025 marks a clear experimental setback for particle-based extensions of the neutrino sector. The failure to detect sterile neutrinos strengthens the case for theories that explain oscillations through **internal dynamics and medium structure**, rather than through an expanding particle zoo.

II. Dark Matter Searches Reach Record Sensitivity — and Find Nothing (LZ, XENONnT)

The news

Throughout 2025, the two most sensitive direct-detection experiments—**LUX-ZEPLIN (LZ)** and **XENONnT**—reported **new world-leading null results**. After unprecedented exposures, **no signal consistent with WIMP dark matter** was observed.

The studies (primary sources)

- **LUX-ZEPLIN Collaboration (2025)**
  Extended WIMP search with ∼417 live days
  - Largest exposure to date for a liquid-xenon detector.
  - Spin-independent cross-section limits pushed to the **neutrino floor** over a wide mass range.
  - Result: **no excess above background**.
- **XENONnT Collaboration (2025), *Physical Review Letters***
  3.1 tonne×year WIMP search
  - Independent confirmation of LZs exclusion power.
  - Entire canonical WIMP window (few GeV–TeV) **severely constrained**.
  - Again: **null detection**.

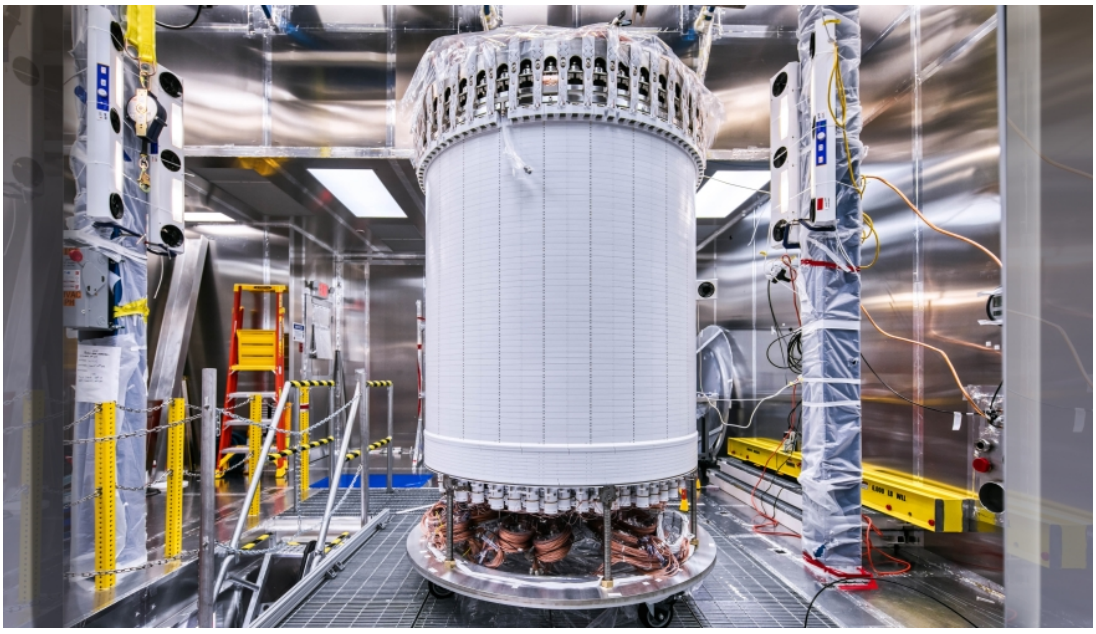

Figure 1: LUX-ZEPLIN detector assembly.

Figure 2: XENONnT detector and underground installation.

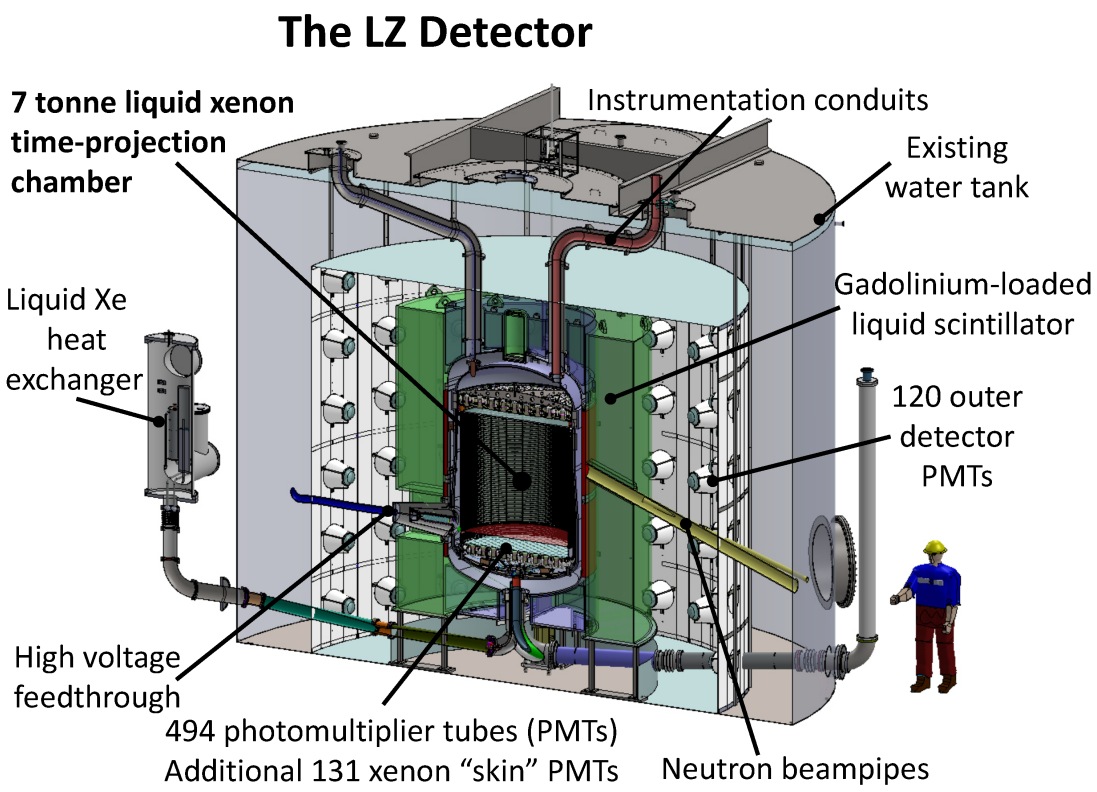

Figure 3: Conceptual layout of the LZ experiment.

These are not preliminary hints or disputed anomalies. They are **final analyses** from mature detectors operating at the limits imposed by irreducible neutrino backgrounds.

Why this strengthens Quarkbase Cosmology

1. The WIMP paradigm is experimentally exhausted For more than three decades, dark matter was assumed to be:

- a **new particle**,
- weakly interacting,
- massive,
- detectable via rare nuclear recoils.

By the end of 2025, this picture is no longer "untested". It is **tested and empty**.

Quarkbase Cosmology **never relied on particle dark matter**. Large-scale gravitational phenomena are attributed to:

- pressure gradients of the Ψ-field,
- geometric redistribution of displaced volume,
- collective effects of ordinary cuarquic matter.

Null results therefore do not create tension for Quarkbase Cosmology; they **remove competition** from an entire class of particle-based explanations.

2. The "neutrino floor" is a conceptual boundary, not a victory Reaching the neutrino floor is often presented as experimental triumph. Ontologically, it is a warning sign:

> further progress by adding particles becomes indistinguishable from known physics.

Quarkbase Cosmology interprets this correctly: when detection becomes background-limited by **known neutrinos**, the universe is signaling that **the phenomenon may not be particle-based at all**.

3. Geometry replaces inventory Dark matter searches ask: *"What particle are we missing?"*
Quarkbase Cosmology asks: *"What structure are we misinterpreting?"*

2025 provides strong empirical motivation for shifting from **particle inventory expansion** to **structural reinterpretation of gravity and cosmology**.

Key takeaway

2025 closes the WIMP chapter without closing the dark-matter problem. When the most sensitive detectors see nothing, explanations based on **field structure and geometry** become not speculative, but necessary.

III. Sub-GeV Dark Matter Searches Also Come Up Empty (SENSEI)

The news

In 2025, attention shifted to **light dark matter**—below the GeV scale—using novel detectors capable of counting **single electrons**. The flagship result came from **SENSEI** at SNOLAB. The outcome was again clear: **no signal**.

The study (primary source)

- **SENSEI Collaboration (2025)**
  First SNOLAB results with skipper-CCD technology
  - Ultra-low threshold detection (single-electron sensitivity).
  - Probes dark matter masses **well below** the reach of xenon experiments.
  - Result: **no excess events** beyond backgrounds; strongest constraints to date in the sub-GeV regime.

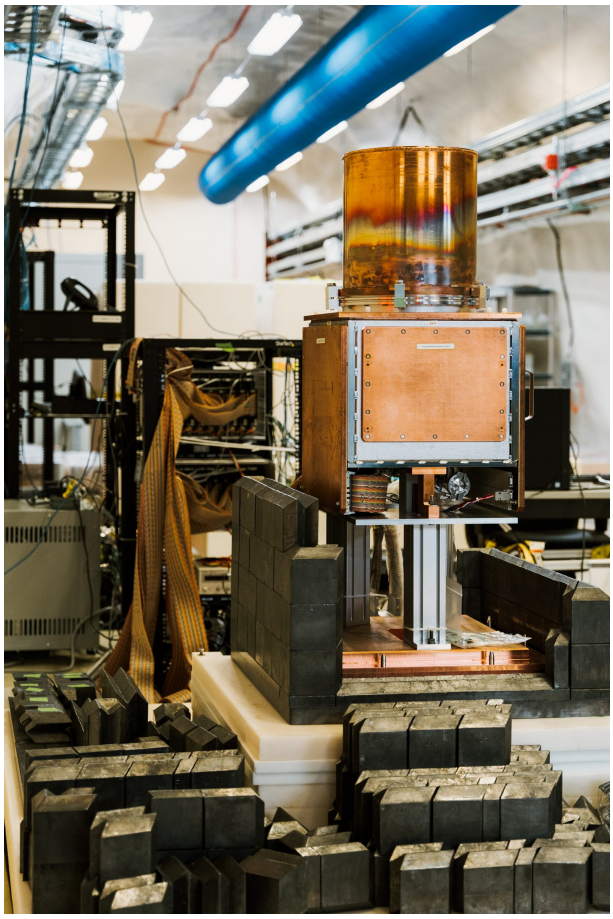

Figure 4: SNOLAB underground laboratory, hosting the SENSEI experiment.

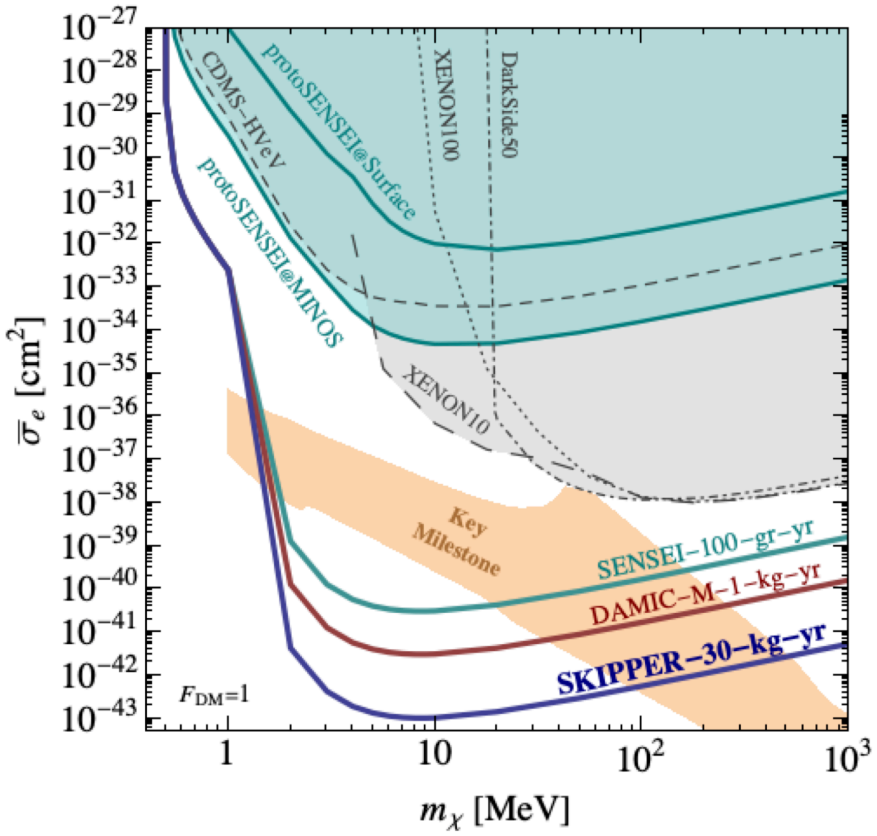

Figure 5: Representative exclusion limits for sub-GeV dark matter from skipper-CCD experiments.

Figure 6: General view of the SNOLAB facility.

This closes what was often presented as the "escape hatch" for particle dark matter after WIMPs failed.

Why this strengthens Quarkbase Cosmology

1. Particle dark matter is failing at *all* mass scales The historical pattern is now unambiguous:

- Heavy particles (WIMPs): excluded → Section 2
- Intermediate candidates: excluded
- **Light particles (sub-GeV): excluded in 2025**

The hypothesis "dark matter is a new particle" is not converging toward a discovery; it is **retreating across parameter space**.

Quarkbase Cosmology does not need to follow this retreat. It never tied cosmic structure to an undiscovered particle species.

2. Technological sophistication exposes ontological weakness SENSEI represents the extreme limit of detector ingenuity: when experiments can literally count **individual electrons** and still see nothing, the absence of signal is no longer a sensitivity issue.

This is precisely the situation in which Quarkbase Cosmologys core claim becomes relevant:

> large-scale gravitational effects do not require additional matter content, but a **misinterpretation of field dynamics**.

3. Structural explanations scale; particle explanations fragment Each null result forces particle models to:

- split into sub-cases,
- introduce new couplings,
- add hidden sectors.

Quarkbase Cosmology scales in the opposite direction:

- same Ψ-field,
- same displaced volume principle,
- same ontology from neutrino to cosmology.

This is not aesthetic preference; it is **structural robustness under experimental pressure**.

Key takeaway

By the end of 2025, particle dark matter is constrained from the TeV scale down to the electron scale. What remains viable are not smaller particles, but **different physical principles**.

IV. Early Massive Galaxies Persist — ΛCDM Remains Under Tension (JWST)

The news

Throughout 2025, analyses based on **JWST** deep-field data continued to report **massive, evolved galaxies at very high redshift**. While astrophysical modeling has been refined, the core pattern persists: **structure appears earlier and more efficiently than ΛCDM naturally predicts**.

The studies (primary sources)

- **James Webb Space Telescope (2024–2025)**
  Multiple peer-reviewed studies using CEERS, JADES, and related programs report:
  - Stellar masses and luminosities at $z \gtrsim 8$–**12** exceeding conservative ΛCDM expectations.
  - Star-formation efficiencies that require either:
    * extreme baryonic tuning, or
    * revisions to early-universe assumptions.

Figure 7: JWST deep-field observations revealing early massive galaxy candidates.

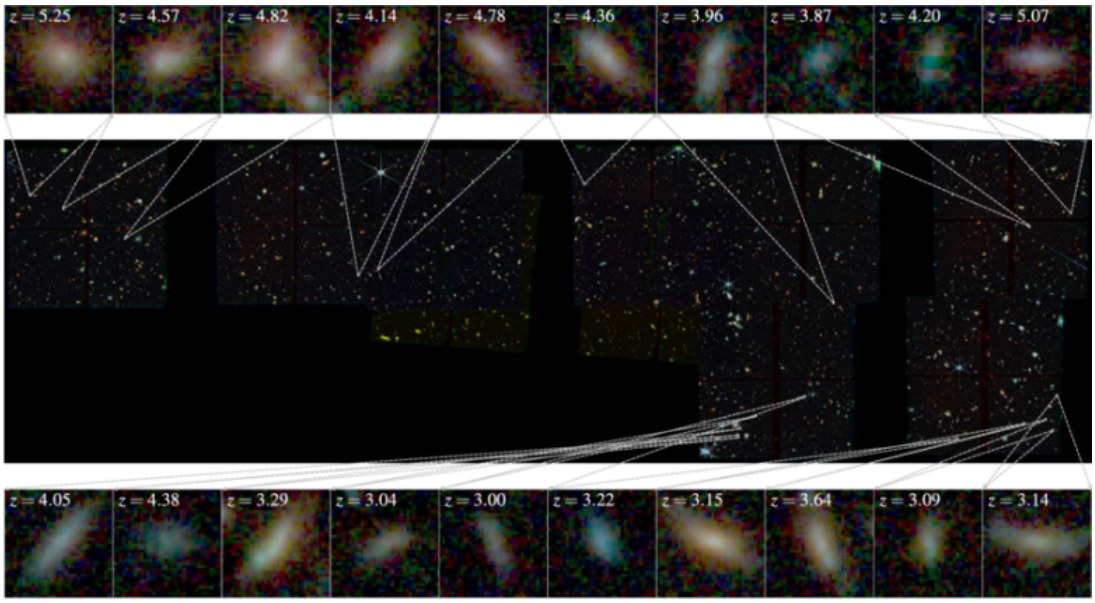

Figure 8: High-redshift disk galaxy candidates identified in JWST datasets.

Figure 9: Representative JWST imagery illustrating early-universe structure.

Importantly, 2025 did **not** "resolve" the issue; it **reframed** it. The community increasingly acknowledges **tension**, even when debate remains over interpretation.

Why this strengthens Quarkbase Cosmology

1. Early structure favors dynamics over inventories ΛCDM explains late-time structure by:

- cold dark matter seeds,
- hierarchical growth,
- long relaxation times.

The repeated appearance of **early, massive systems** strains this narrative unless one invokes finely tuned efficiencies or rapid feedback loops.

Quarkbase Cosmology predicts **fast structural organization** as a natural consequence of:

- Ψ-field gradients,
- non-particle gravitational dynamics,
- absence of a need for slow CDM clumping.

Early structure is not anomalous in Quarkbase Cosmology; it is **expected**.

2. No dependence on inflationary patchwork Many ΛCDM "fixes" for early structure lean on:

- modified inflation,
- early dark energy episodes,
- parameter extensions.

Quarkbase Cosmology does not rely on inflation as a physical entity. Structure formation follows from **medium relaxation**, not from finely tuned initial conditions.

As JWST pushes observations earlier, models that depend on special initial conditions become increasingly fragile.

3. Observational pressure is directional The key point is not that ΛCDM is "falsified", but that:

- each JWST cycle **adds pressure in the same direction**,
- no comparable pressure accumulates against medium-based cosmologies.

This asymmetry matters. A theory that remains comfortable as data move earlier in cosmic time is structurally advantaged.

Key takeaway

JWST in 2025 did not close the debate on early galaxies — it stabilized the tension. Persistent early structure aligns naturally with **field-based cosmologies** and increasingly challenges particle-centric narratives of cosmic assembly.

V. Precision Physics Tightens the Screws — The Muon g−2 Endgame (Fermilab)

The news

In 2025, the **final high-precision result** of the muon anomalous magnetic moment was released, completing the long campaign at **Fermilab**. The measurement reached its ultimate accuracy and forced a reassessment of how much room remains for parameter-based extensions of the Standard Model.

The study (primary source)

- **Fermilab Muon g−2 Collaboration (2025)**
  Final combined measurement of the muon anomalous magnetic moment
  - World-leading precision at the **ppm level**.
  - Confirms a persistent discrepancy relative to long-standing Standard Model predictions **or** demands substantial reworking of hadronic contributions within the same framework.
  - Either way, the result **compresses** the viable theory space.

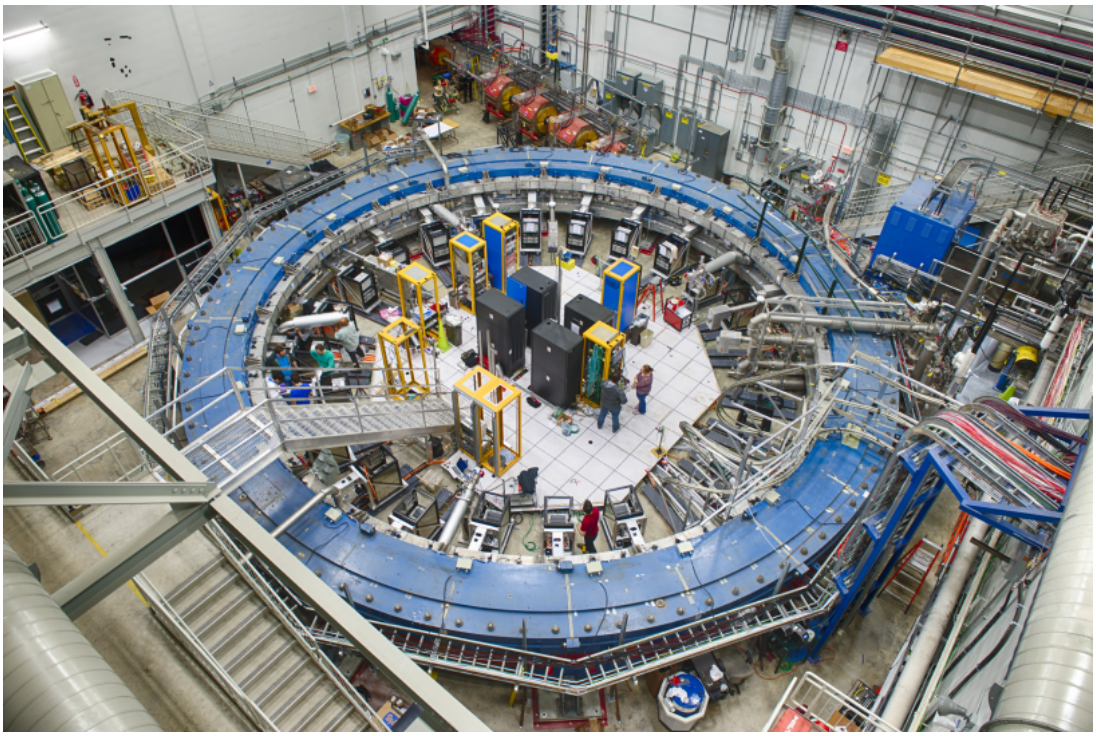

Figure 10: Muon g−2 storage ring at Fermilab (E989 experiment).

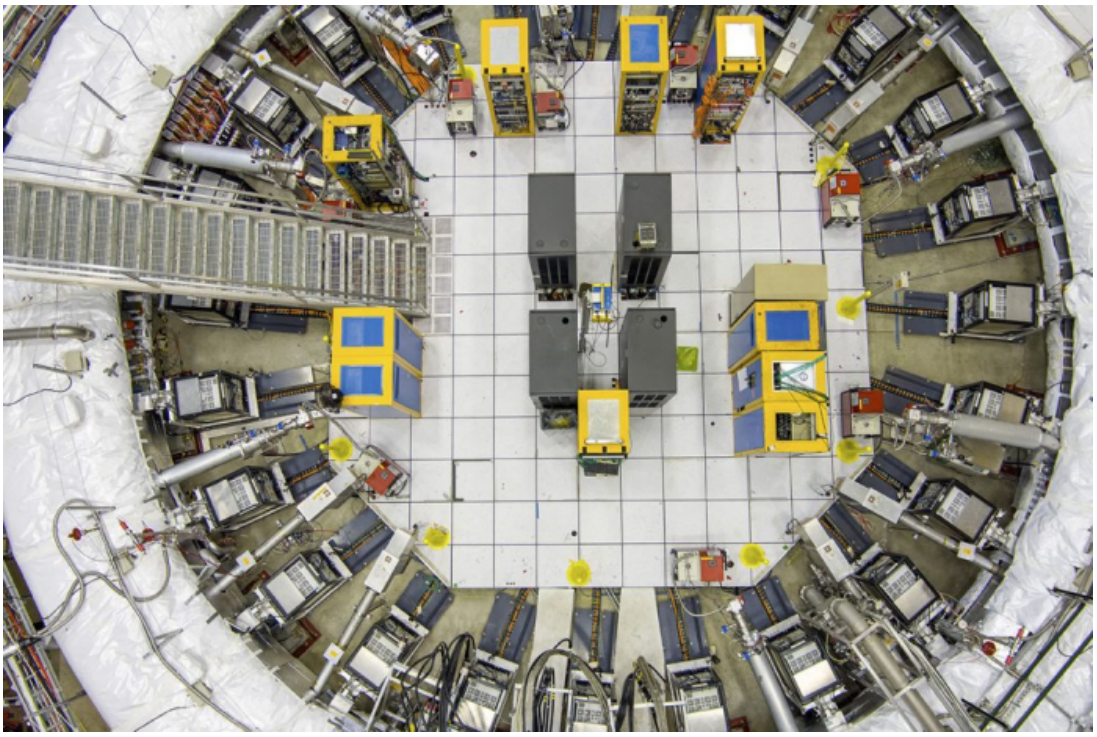

Figure 11: Overhead view of the Fermilab Muon g−2 experimental setup.

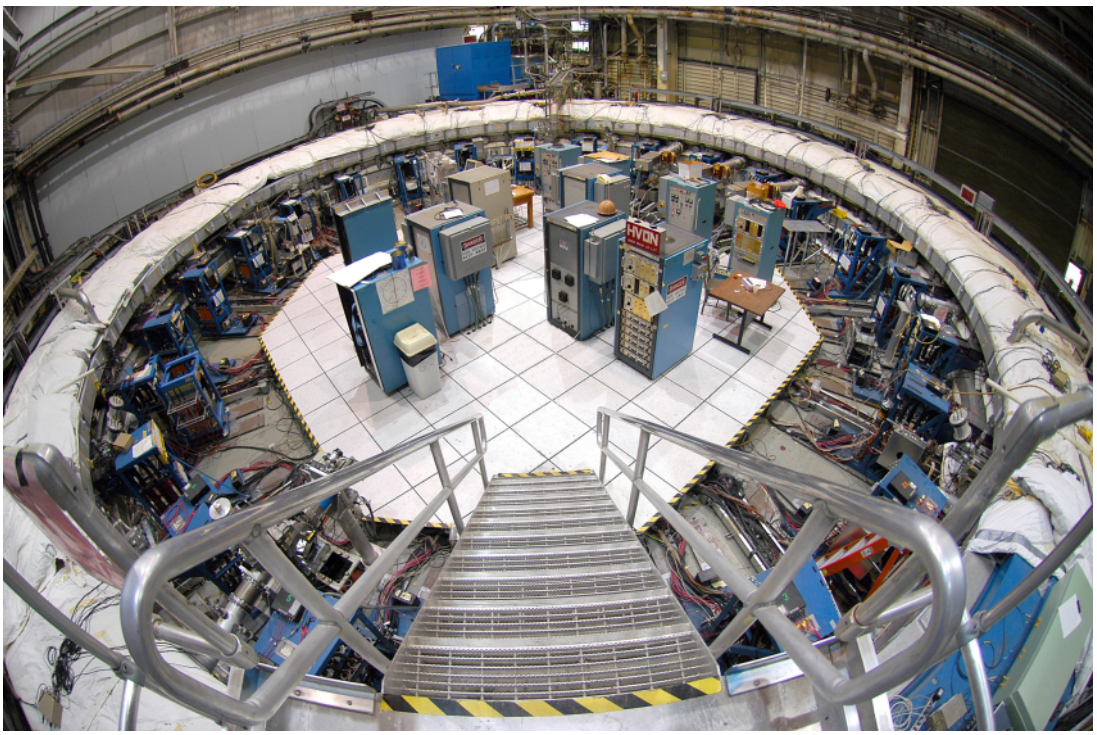

Figure 12: Historical view of the muon storage ring during earlier stages of the g−2 program.

This is not an anomaly announcement; it is the **closure** of an experimental program.

Why this strengthens Quarkbase Cosmology

1. Parameter tuning reaches diminishing returns If the discrepancy is upheld, the Standard Model requires:

- delicate hadronic recalculations,
- or additional virtual contributions.

If it is absorbed by recalibration, the lesson is the same: **precision physics is now limited by model elasticity**, not by measurement.

Quarkbase Cosmology does not hinge on loop-by-loop cancellations. Magnetic moments emerge from **geometric torsion and mode structure** of compactations (e.g., $N = 13$ for the electron), not from an accumulation of virtual particles.

2. Precision favors structural origins over additive fixes As experiments enter the ppm and sub-ppm regime, adding new particles becomes increasingly risky: each addition propagates inconsistencies elsewhere.

Quarkbase Cosmology offers a different scaling behavior:

- fewer entities,
- more internal structure,
- corrections tied to **geometry**, not to new degrees of freedom.

This is exactly the regime where structural theories outperform inventory-based ones.

3. A convergence signal across domains Taken together with:

- sterile-neutrino exclusions (Section 1),
- dark-matter null results (Sections 2–3),
- cosmological tensions (Section 4),

the muon g−2 endgame fits a single pattern: **physics is not asking for more particles; it is asking for deeper structure**.

Key takeaway

2025 marks the point where precision experiments stop opening doors and start closing them. When parameters are squeezed to exhaustion, theories grounded in **geometric and field structure** gain decisive relevance.

Executive Synthesis, Quarkbase Cosmology Justification, and Reference Block

Executive synthesis: what 2025 actually did

Across independent domains, 2025 delivered a single, coherent empirical message:

1. **Particle multiplication is not being rewarded by Nature.**
   Sterile neutrinos (as a patch) lose ground; WIMPs remain absent; light-DM escape routes are increasingly constrained.
2. **Precision is no longer "discovering"; it is "closing."**
   The experimental frontier is now dominated by exclusion power and consistency stress tests.
3. **Cosmology is drifting toward "structure-first."**
   Early structure keeps tensioning ΛCDM; explanations require either increasingly tuned baryonic prescriptions or deeper revisions.

This is exactly the regime where Quarkbase Cosmology is designed to operate: **one ontology (Ψ-field + compactations), internal modes, geometric necessity, no auxiliary particle zoo**.

The Quarkbase Cosmology justification

A) Quarkbase Cosmology as the opposite of patch-physics

Mainstream extensions typically respond to tension by adding:

- new particles,
- new sectors,
- new couplings,
- new parameters.

Quarkbase Cosmology responds by adding **none of the above**. It replaces them with:

- a real medium (Ψ-field),
- discrete compactations (N-sequence),
- **internal modal structure** as the generator of "flavor-like" phenomenology,
- geometry as the source of "constants."

That conceptual stance is not rhetorical; it is falsifiable and programmatic.

B) 2025 rewarded economy, not inflation

Every null result is not "nothing happened." It is a **directional selection** against classes of hypotheses. 2025 selected against:

- sterile-neutrino patching,
- WIMP dominance,
- "just go lighter" dark-matter fixes.

Quarkbase Cosmology is not "helped" by a single null result; it is helped by the **pattern**: repeated closure of particle-based escape hatches.

C) Interpretative stability under new data

When experimental and observational results push toward earlier cosmic epochs (JWST), higher detection sensitivity (LZ / XENONnT / SENSEI), and finer precision measurements ($g-2$), the Quarkbase Cosmology framework does not require the introduction of new physical entities.

Instead, its explanatory relevance increases, as alternative approaches rely on progressively more *ad hoc* extensions to accommodate the same empirical pressure.

Reference block

1. **KATRIN Collaboration (2025), *Nature.***
   Sterile-neutrino search based on 259 days of KATRIN data.
   DOI: 10.1038/s41586-025-09739-9
2. **LUX-ZEPLIN (LZ) Collaboration (2025).**
   WIMP search results with extended exposure (≈417 live days).
   Preprint DOI: 10.48550/arXiv.2512.08065
3. **XENONnT Collaboration (2025), *Physical Review Letters.***
   WIMP search with 3.1 tonne×year exposure.
   Preprint DOI: 10.48550/arXiv.2502.18005
4. **SENSEI Collaboration (2025).**
   First direct-detection results on sub-GeV dark matter using skipper-CCD technology.
   DOI: 10.1103/PhysRevLett.134.011804
5. **Muon g−2 Collaboration (Fermilab) (2025).**
   Final combined measurement of the muon anomalous magnetic moment.
   Publication DOI: forthcoming

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[1] C. Omeñaca Prado (2025). *Neutrino Oscillations as Internal Mode Interference in the Vacuum Pressure Field.*

[2] C. Omeñaca Prado (2025). *General Cosmology of Quarkbase (Neutrino).*

[3] C. Omeñaca Prado (2025). *List of observed phenomena unexplained by the Standard Model that the Cosmology of the Quarkbase will address one by one.*